UCRL-JC-135316
PREPRINT

# Recent Results from the National Transparent Optical Network (NTON)

H. Feng
R.L. Thombley
W.J. Lennon
J.P. Heritage

This paper was prepared for submittal to the
12th Annual Meeting of the Institute for Electrical and
Electronics Engineers Lasers and Electro-Optics Society
San Francisco, CA
November 8-11, 1999

**July 21, 1999**

# Recent Results from the National Transparent Optical Network (NTON) (Invited)

Helena Feng, R. Lee Thombley, William J. Lennon
Lawrence Livermore National Laboratory
Advanced Telecommunications Program
Livermore, California 94550
Tel: (925) 422-0760 Fax: (925) 424-2707
feng2@llnl.gov

Jonathan P. Heritage
University of California
Department of Electrical and Computer Engineering
Davis, California 95616
Tel: (530) 752-6289 Fax: 530-754-9217
heritage@ece.ucdavis.edu

## Abstract

We review the NTON program, its design and its recent progress on deployment. We then focus on one aspect of our design process, namely modeling the links of the network at the physical layer.

This work reported was sponsored in part by the Department of Defense Advanced Research Projects Agency (DARPA) and the National Transparent Optical Network Consortium which included work under the auspices of the U. S. Department of Energy by Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

# Recent Results from the National Transparent Optical Network (NTON) (Invited)

Helena Feng, R. Lee Thombley, William J. Lennon
Lawrence Livermore National Laboratory
Advanced Telecommunications Program
Livermore, California 94550
Tel: (925) 422-0760 Fax: (925) 424-2707
feng2@llnl.gov

Jonathan P. Heritage
University of California
Department of Electrical and Computer Engineering
Davis, California 95616
Tel: (530) 752-6289 Fax: 530-754-9217
heritage@ece.ucdavis.edu

The National Transparent Optical Network (NTON) is co-funded by the Defense Advanced Research Projects Agency (DARPA) and the National Transparent Optical Network Consortium (NTONC). Members of the NTONC include Nortel Networks, GST Telecommunications, Lawrence Livermore National Laboratories (LLNL), Sprint Communications and the Bay Area Rapid Transit District (BART). NTON provides a 10+ Gb/s open research platform for Next Generation Internet (NGI) trials. NTON is a 2000 km 10-20 Gb/s wavelength division multiplexed (WDM) network deployed using in-place commercial fiber. NTON links reaching government, university and private sector labs and provides the ability to interface with most of the broadband research networks in the US. Planned interchange networks are: ATDnet, HSCC, DREN, NREN, ESnet, vBNS, SVTT, Abilene, Canarie, CalREN, and others. NTON will simultaneously support device design R&D, network R&D and testing of high bandwidth enabled applications. NTON provides direct access to nearly all of the major universities on the West Coast at data rates up to, and potentially beyond, 2.5 Gb/s. NTON will also connect major West Coast supercomputer sites, digital libraries, high energy physics labs and medical research institutions.

Fig.1 is a functional diagram of NTON. The north-south stretch is a 10 Gb/s bi-directional backbone connecting Seattle, Portland, San Francisco Bay Area, Los Angeles and San Diego, with opto-electro-optical regenerators at each of the above nodes. The transparent ring in the San Francisco Bay Area has 2.5 x 8 Gb/s capability. The three optically switched nodes on the ring are located in Livermore (LLNL), Oakland (GST) and Burlingame (Sprint).

One of the challenges in engineering such a large scale WDM optical network is to assess the physical layer impairments the transmitted signals accumulate as they propagate through cascades of optical fiber segments, EDFAs, and switching elements and to find effective methods to overcome them. Computer simulation is a very important and cost effective tool to do just that before expensive network components are installed. Models of transmitters, EDFAs, optical filters, optical fiber, and receivers are developed using the characteristics of each component. These models are then verified against measurement. Simulations of optical signals propagating through optical links that are built with cascades of these components are carried out to estimate the bit-error-rate, which is an important measure of signal quality.

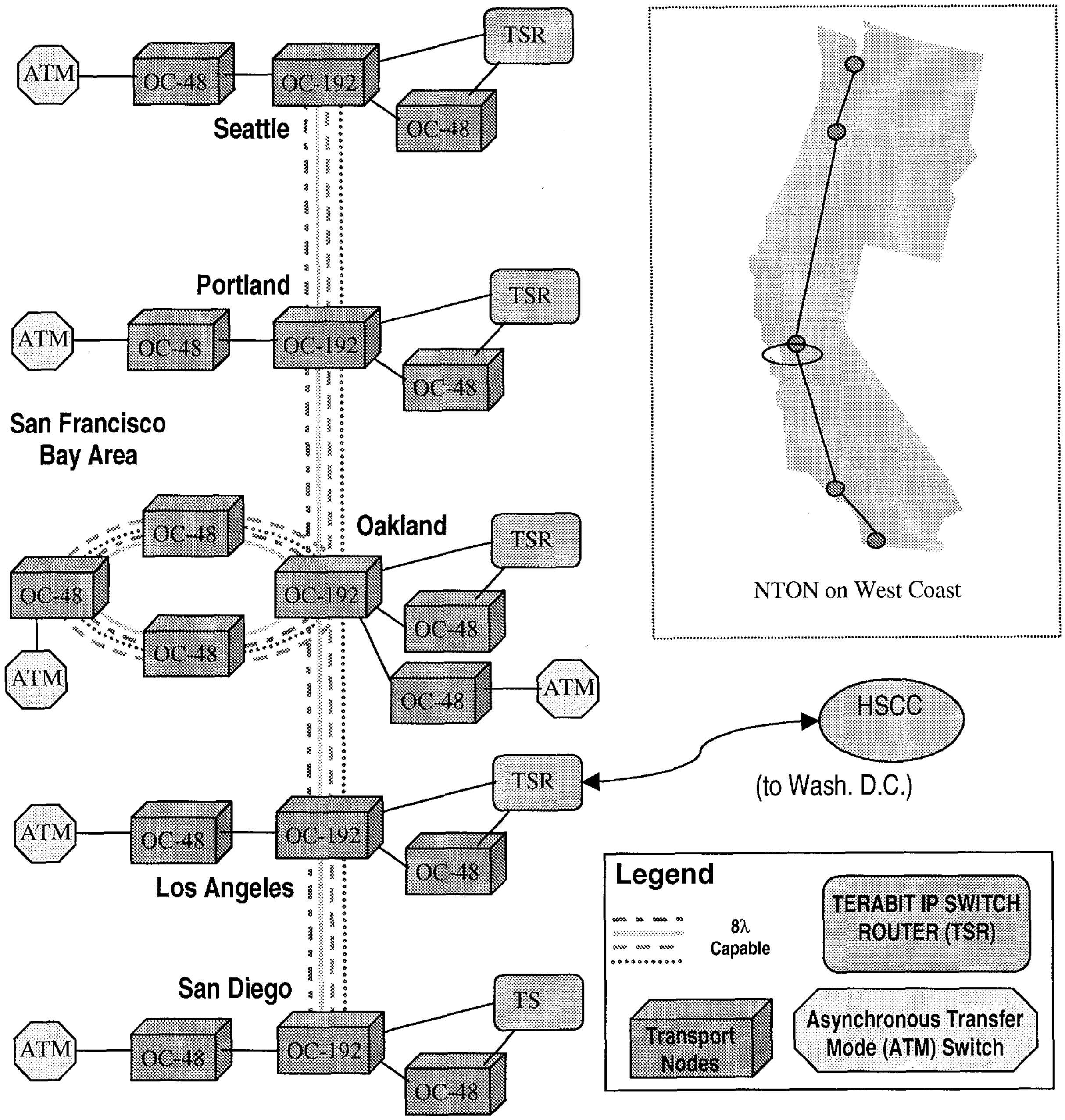


Fig 1. Functional Diagram of NTON